QUEUING CONFIGURATION IN SATELLITE COMMUNICATION

S. Maragathasundari
Associate professor, Department of Mathematics, Kalasalingam Academy of Research and Education Krishnankoil, (India).
E-mail: maragatham01@gmail.com.
ORCID: https://orcid.org/0000-0003-1210-6411

G. Ammakkannu
Associate Professor, Department of Mathematics, Kalasalingam Academy of Research and Education, Krishnankovil, (India).
E-mail: ammakannu1975@gmail.com.
ORCID: https://orcid.org/0000-0002-8789-2093

P. Manikandan
Assistant Professor, Department of Electronics and Communication Engineering, Kalasalingam Academy of Research and Education, Krishnankovil, (India).
E-mail: maanip85@gmail.com.
ORCID: https://orcid.org/0000-0002-5737-0235

Recepción: 25/10/2019 **Aceptación:** 24/08/2020 **Publicación:** 30/11/2021

Citación sugerida:
Maragathasundari, S., Ammakkannu, G., y Manikandan, P. (2021). Queuing configuration in satellite communication. *3C Tecnología. Glosas de innovación aplicadas a la pyme, Edición Especial,* (noviembre, 2021), 179-197. https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

ABSTRACT

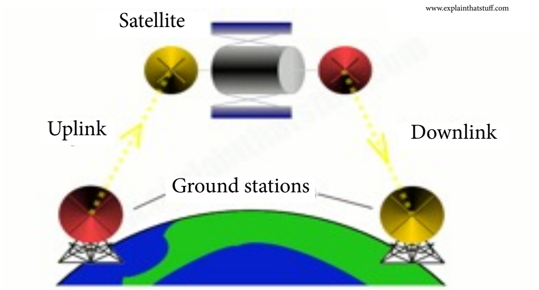
Satellite correspondence frameworks have been utilized for a considerable length of time to give fixed point and versatile administrations to the business and military markets around the world. The procedure completed in satellite correspondence is changed over as a Queuing issue and the issue is settled by methods for Supplementary variable technique of Queuing. It results in the derivations of the Queue execution proportions of the framework which causes the procedure to recognize the deformities in the process. It likewise gives the thought regarding the uplift of the methods in satellite correspondence systems which prompts a smooth running of the communication in a profitable manner. Numerical outline and Graphical portrayal given toward the end makes an intricate thought regarding the lining procedure occurring in satellite correspondence.

KEYWORDS

Delay, Compulsory vacation, Reneging, Feedback service.

1. INTRODUCTION

Services incorporate two-way media communications, route, and TV and radio telecom. As in most present-day remote frameworks, satellite correspondences transfer speeds have developed after some time with advanced information rates beginning from kilobits every second (Kbps) to current framework wide limit of more than 100 gigabits for each second (Gbps).



Graphic 1. Satellite communication.
Source: own elaboration.

There is currently extraordinary improvement in the arrangement of new high throughput satellite broadband arrangements equipped for conveying web, voice, video and other special interchanges administrations. Real administrators and supporters either have propelled or are making arrangements for a wide scope of uses, including purchaser as well as gas and oil, calamity recuperation, aeronautical, oceanic, military and other mission basic prerequisites. For each satellite arrangement, there is a lot bigger arrangement of earthbound based frameworks, or ground stations, extending from satellite control offices to end-client gadgets. The approval, support and investigating of these ground stations regularly requires a mix of indoor and outside testing of various RF and IF subsystems and segments. Lam (1980) studied this paper in general about the models on multilevel diversity coding.

Fantacci and Zoppi (2000) studied the performance of different polling systems used in wireless local networks where the transmission channel exhibits a non-stationary behavior. Yeung and Zhang (1999) discussed about the maximum channel throughput of CSMA approaches unity in the limit of very long queues. Giambene and Kota (2006) suggested a

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

work in detail about the interaction of different layers that can be permitted to improve the higher-layer goodput as well as user satisfaction.

Hung, Montpetit, and Kesidis (1998) describes an ATM-based satellite network, focusing on the networking (ATM) aspects of the design. Chang and Lin (1993) studied the performance of VSAT-based satellite wide area networks. Basic geostationary and non-geostationary satellite constellations are considered. Financial success of satellite personal communication systems was examined by Lutz (1998). Louvros, Pylarinos, and Kotsopoulos (2007) investigated a new model which is proposed with a dedicated queue for each transceiver in the cell.

Zaim (2003) calculated a new call and hand-off call blocking probabilities in LEO satellite networks carrying voice calls. Maragathasundari (2015) derived the execution measures for a mass section queuing model of three periods of organization with different journey strategies. Maragathasundari *et al.* (2017) described a non-markovian queuing model of restricted admissibility and service interruption in which entry was taken after a Poisson method. Zhu *et al.* (2012) discussed about the Load Balancing Routing Based on Agent for Polar-orbit LEO satellite networks. Maragathasundari and Karthikeyan (2016) investigated a mass queuing model with short and long escape.

1.1. COMMUNICATIONS SATELLITES

Communications satellites are "space mirrors" that can help us bounce radio, TV, Internet data, and other kinds of information from one side of Earth to the other.

1.2. UPLINKS AND DOWNLINKS

In the event that you need to send something like a TV communicates from one side of Earth to the next, there are three phases included. To start with, there's, where information is channeled up to the satellite from a ground station on Earth. Next, the satellite procedures the information utilizing various installed transponders (radio recipients, intensifiers, and transmitters). These lift the approaching sign and change their recurrence, so approaching sign don't get mistook for active ones. Various transponders in a similar satellite are utilized to deal with various TV stations carried on various frequencies. At last, there's the downlink, where information is sent down to another ground station somewhere else on

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

Earth. Despite the fact that there's generally only a solitary uplink, there might be a large number of downlinks, for instance, if numerous individuals are getting a similar satellite TV signal without a moment's delay. While a correspondences satellite may transfer a sign between one sender and beneficiary (started up into space and withdraw once more, with one uplink and one downlink), satellite communicates commonly include at least one uplink (for at least one TV stations) and different downlinks.

The above communication progression is converted as a Queuing problem. The problems faced in the process are diagnosed and the corresponding performance measures of the Queuing system of the satellite communication are derived. The communication procedure is explained in terms of Queuing parameters as Stages of service, Delay, compulsory vacation, Reneging and feedback service

1.3. STAGE 1: DELAY PROCESS

Much like some other correspondences' medium: inertness is the time taken for data to go from the inception to the goal and possibly for the reaction to return.

Dormancy in satellites is particularly progressively evident due to the exceptionally long separations that the sign must go into space and back. The separation voyaged relies upon the area of the satellite and along these lines its circle. There are three primary satellite sorts utilized in satellite correspondences:

1) Geostationary/geosynchronous/GEO: these satellites stay in a generally fixed position in the sky contrasted with a situation on the equator. In this way you don't have to modify your reception apparatus and it is dependably in a known relative position in the sky. These satellites are around 32,786km from the Earth.
2) Low Earth Orbit (LEO): The Iridium satellites are just 781km from the surface there are bunches of them and they cooperate like a flying cell arrange.
3) Medium Earth Orbit (MEO): It has another player financially with O3b circling at 8063km, they will have less satellite, giving lower dormancy than GEO however more limit and less satellites than Iridium.

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

1.4. COMPULSARY VACATION

On-orbit satellite servicing will elongate the life of some very expensive satellites. Its application areas are very broad where each one has its own importance based on scientific, economic, strategic, and societal benefits. Repair and maintenance of the satellites in space keep a unique and valuable asset operational, essentially improving it beyond its design lifetime or the reliability of its subsystems. It improves overall mission robustness and offers a unique capability to improve risk posture through post-launch operations.

The process of on-orbit satellite is very simple. For the purpose, a service spacecraft is built with robotic arms. The major components here include an advanced spacecraft with a specialized toolkit and robotic arms just like humans for capturing, interacting with, and manipulating a client, software for managing semi-autonomous servicing tasks, and an advanced sensor suite for careful rendezvous and proximity operations. In case when any satellite developing a snag is discovered, the servicing spacecraft is made to approach it, grab it, pull it close, and repair or exchange the faulty part with a toolkit it is carrying. If a satellite runs out of the fuel, similar technology is used to refuel it.

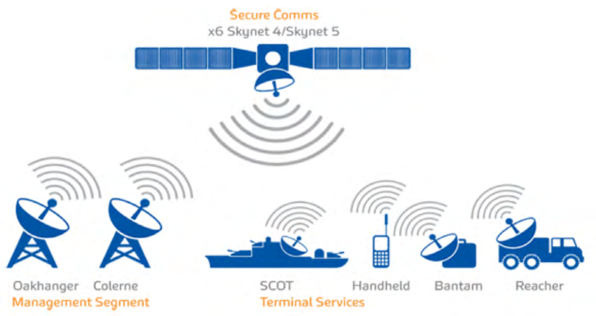
In past, it was not possible to repair all satellites in orbit. It was mandatory to build them accordingly so that they can be serviced. Like for example when all three-rubidium clock of IRNSS 1A satellite failed, then it was pushed to graveyard. The satellite was launched by Indian space and research organization (ISRO) as the first in the queue of India's own regional navigation system, NAVIC. But today the technology has matured and can repair all satellites on orbit. The Servicer designed SSL is compatible with most government and commercial spacecraft that are currently in orbit, even those not designed to be serviced in space.

1.5. STAGE 2: (OPTIONAL)

If the satellite is not working properly even after the maintenance done at the compulsory vacation, the satellite may go for an extended optional vacation. Luckily, the propelled apply autonomy installed new satellite overhauling undertakings are planned to lessen the quantity of satellites confronting this sort of inopportune retirement. Overhauling rocket can fix, reposition, and refuel satellites utilizing automated arms, and will in the long run

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

have the option to collect satellites altogether in space. Satellite overhauling could wipe out the requirement for governments and organizations to contribute millions — and once in while billions — into structuring, building, and propelling a substitution satellite each time fixes or fuel are required. Overhauling would likewise serve a national security job, the same number of government satellites hand-off basic data that shouldn't be disturbed. The innovation even can possibly enable people to achieve Mars.



Graphic 2. Satellite service.
Source: own elaboration.

1.6. RENEGING

Likewise, because of restlessness clients may leave the framework subsequent to joining the line. This procedure of reneging happens during mandatory excursion with parameter γ.

The clients/clients are holding up at the less than desirable end to get any sort of valuable data which are to be sent by the transponders at the uplink stations. Be that as it may, the procedure of gathering, might be postponed a ton during the movement of necessary support.

Consequently, the client may become irritated and they are not willing to remain back in the line. Thus, they will look for some other downlink station to show signs of improvement gathering of sign on schedule. Henceforth reneging happens.

1.7. FEEDBACK SERVICE

Furthermore, if the client is disappointed with the administration, they can decide on an input administration with likelihood p.

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

Criticism administration is essential, if the sign sent by the transponder isn't appropriately gotten by the end clients. Henceforth the undesired or undesirable sign got at the recipient may nourished back again to get the unadulterated type of sign. i.e. signal without clamor. So as to keep away from this sort of loud flag, we have to avert our framework with considerably more proficiency.

So as to give high throughput, the inertness ought to be low. There were a few stages which are recorded underneath, to diminish the input administrations. A large number of these arrangements hazard creating more flotsam and jetsam from impacts, and all future costly and disputable. Another methodology is to forestall space crashes in any case through better traffic control. Today, satellite administrators don't have exact orbital parameters for different satellites that may represent a danger of impact. Just a couple of nations — primarily the United States, and somewhat China, Europe, and Russia — approach exact following information, and that data is stayed quiet, in case it uncovers insights concerning the advanced instrumentation used to assemble it.

Military organizers have since quite a while ago discussed the requirement for "space situational mindfulness", and the military tracks satellites for its very own motivations. But the inexorably jam-packed nature of close earth circles, in addition to the risk presented by crash flotsam and jetsam, has driven numerous to contend that we need comparable following abilities for the regular citizen area. The shabby method to do this is to make a portion of the military information open; the costly way is manufacturing a different, absolutely regular citizen following framework. The parts utilized for the uplink and downlink correspondence ought to be very much prepared with no harms. The gear used for this sort of correspondence ought to be kept up appropriately, with a wide range of approval procedures to give productive sign at the less than desirable end.

2. METHODOLOGY OF SOLVING THE ABOVE QUEUING ISSUE

2.1. METHODOLOGY

The above queuing issue is solved by supplementary variable technique of queuing theory.

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

First, we outline the administering conditions for the lining issue engaged with satellite correspondence concentrate in area 4 by utilizing the boundaries like help rendered, short excursion, long get-away, delay in getting into upkeep work, reneging, input administration and phases of administration. Here help is rendered into two phases which make the framework to work out in a simplicity way.

As a subsequent advance, we process out the underlying limit states of the issue characterized.

Next by the utilization of different advantageous factors, we infer the likelihood creating capacity of the line size of the satellite correspondence lining issue. In continuation, length of the line, number of clients (attempts to be completed) in the framework, holding up time of the clients in the line just as in the framework are inferred.

2.2. BENEFITS

All the deductions are defended by methods for numerical outline and graphical depiction. In light of that, examination have been made in the numerical investigation and the investigation is done in the examination report. Having a profound report on the examination, one can get limiting the defer procedure in getting into the excursion method in the Satellite. Additionally, framework support work is required whether for shorter length or longer span could be anticipated. This investigation assists with doing the different components in correspondence issue in an exact way. This prompts the length of the line to be negligible in the framework. Use factor would be made to a maximal. Satellite correspondence framework attempts to a maximal level.

3. ASSUMPTIONS UNDER LYING THE MODEL

Customers arrive in groups to the Queuing system (In the process of communication).

Clients arrive in batches to the system modelling supermarkets with mean arrival rate $\lambda > 0$.

λe_k (k = 1 to n) be the first order probability that a batch of r customers arrive at the system.

Here, $0 \leq e_k \leq 1$ and $\sum_{k=1}^{n} e_k = 1$

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

For the first stage of service, $S_n^{(1)}(x)$,$\theta_1(x)$ is the conditional probability of completion of completion of first stage of service. The probability distribution function of the first stage of service and its corresponding density function are given by $G_1^*(x)$ and $g_1^*(x)$.Hence

$$\theta_1(x) = \frac{g_1^*(x)}{1 - G_1^*(x)}, \quad g_1^*(x)(s) = \theta_1(s)e^{-\int_0^s \theta_1(x)dx}$$

Similarly for all the other parameters Delay process $(D_n(x))$, Compulsory vacation $(M_n(x))$, Stage 2 process $(S_n^{(2)}(x))$ we have the following functions respectively:

$$\theta_j(x) = \frac{g_j^*(x)}{1-G_j^*(x)}, \quad g_j^*(x)(s) = \theta_j(s)e^{-\int_0^s \theta_j(x)dx}, \text{j} = 2, 3, 4$$

4. STEADY STATE CONDITIONS OVERSEEING THE FRAMEWORK

$$\frac{d}{dx}S_n^{(1)}(x) + (\lambda + \theta_1(x))S_n^{(1)}(x) = \lambda \sum_{k=1}^n e_k S_{n-k}^{(1)}(x). \tag{1}$$

$$\frac{d}{dx}S_0^{(1)}(x) + (\lambda + \theta_1(x))S_0^{(1)}(x) = 0. \tag{2}$$

$$\frac{d}{dx}D_n(x) + (\lambda + \theta_2(x))D_n(x) = \lambda \sum_{k=1}^n e_k D_{n-k}(x). \tag{3}$$

$$\frac{d}{dx}D_0(x) + (\lambda + \theta_2(x))D_0(x) = 0. \tag{4}$$

$$\frac{d}{dx}M_n(x) + (\lambda + \theta_3(x) + \gamma)M_n(x) = \lambda \sum_{k=1}^n e_k M_{n-k}(x) + \gamma M_{n+1}(x). \tag{5}$$

$$\frac{d}{dx}M_0(x) + \big(\lambda + \theta_3(x)\big)M_0(x) = 0. \tag{6}$$

$$\frac{d}{dx}S_n^{(2)}(x) + (\lambda + \theta_4(x))S_n^{(2)}(x) = \lambda \sum_{k=1}^n e_k S_{n-k}^{(2)}(x). \tag{7}$$

$$\frac{d}{dx}S_0^{(2)}(x) + \big(\lambda + \theta_4(x)\big)S_0^{(2)}(x) = 0. \tag{8}$$

$$\lambda Q = (1 - r)\int_0^\infty M_0(x)\theta_3(x)dx + (1 - p)\int_0^\infty S_0^{(2)}(x)\,\theta_4(x)dx. \tag{9}$$

The following boundary conditions are used to solve the above equations.

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

$$S_n^{(1)}(0) = (1-r)\int_0^\infty M_{n+1}(x)\,\theta_3(x)dx + p\int_0^\infty S_n^{(2)}(x)\theta_4(x)dx + (1-p)\int_0^\infty S_{n+1}^{(2)}(x)\theta_4(x)dx. \quad (10)$$

$$D_n(0) = \int_0^\infty S_n^{(1)}(x)\,\theta_1(x)dx. \quad (11)$$

$$M_n(0) = q\int_0^\infty D_n(x)\,\theta_2(x)dx. \quad (12)$$

$$S_n^{(2)}(0) = r\int_0^\infty M_n(x)\theta_3(x)dx. \quad (13)$$

5. DISTRIBUTION OF THE QUEUE LENGTH AT ANY POINT OF TIME

Multiply (1) by z^n and sum over n from 1 to ∞ and add it to (2) results in the following equation

$$\frac{d}{dx}S_n^{(1)}(x,z) + (\lambda - \lambda E_k(z) + \theta_1(x))S_n^{(1)}(x,z) = 0. \quad (14)$$

$$\frac{d}{dx}D_n(x,z) + (\lambda - \lambda E_k(z) + \theta_2(x))D_n(x,z) = 0. \quad (15)$$

$$\frac{d}{dx}M_n(x,z) + \left(\lambda - \lambda E_k(z) + \gamma - \frac{\gamma}{z} + \theta_3(x)\right)M_n(x,z) = 0. \quad (16)$$

$$\frac{d}{dx}S_n^{(2)}(x,z) + (\lambda - \lambda E_k(z) + \theta_4(x))S_n^{(2)}(x,z) = 0. \quad (17)$$

Similarly,

$$zS_n^{(1)}(0,z) = (1-r)\int_0^\infty M_n(x,z)\theta_3(x)dx + p\int_0^\infty S_n^{(2)}(x,z)\theta_4(x)dx + (1-p)\int_0^\infty S_n^{(2)}(x,z)\theta_4(x)dx + \lambda(E_k(z)-1)Q. \quad (18)$$

$$D_n(0,z) = \int_0^\infty S_n^{(1)}(x,z)\theta_1(x)dx. \quad (19)$$

$$M_n(0,z) = q\int_0^\infty D_n(x,z)\theta_2(x)dx \quad . \quad (20)$$

$$S_n^{(2)}(0,z) = r\int_0^\infty M_n(x,z)\theta_3(x)dx. \quad (21)$$

Now integrating (14) from 0 to x, it gives

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

$$S_n^{(1)}(x,z) = S_n^{(1)}(0,z)e^{-(\lambda-\lambda E_k(z))-\int_0^x \theta_1(t)dt}. \tag{22}$$

Integrating the above by parts,

$$S_n^{(1)}(z) = S_n^{(1)}(0,z)\left(\frac{1-G_1^*(w)}{w}\right), w = \lambda - \lambda E_k(z). \tag{23}$$

Where $G_1^*(w) = \int_0^\infty e^{-(\lambda-\lambda E_k(z))x} dG_1(x)$ is the Laplace Stieltje's transform of the service time.

Again multiply (22) by $\theta_1(x)$ and integrating,

$$\int_0^\infty S_n^{(1)}(x,z)\theta_1(x)dx = S_n^{(1)}(0,z)G_1^*(w) \ . \tag{24}$$

Similarly, from the other parameters, we have

$$D_n(z) = D_n(0,z)\left(\frac{1-G_2^*(w)}{w}\right). \tag{25}$$

$$\int_0^\infty D_n(x,z)\theta_2(x)dx = S_n^{(1)}(0,z)G_1^*(w)G_2^*(w). \tag{26}$$

$$M_n(z) = M_n(0,z)\left(\frac{1-G_3^*(k)}{k}\right), k = \lambda - \lambda E_k(z) + \gamma - \frac{\gamma}{z}$$

$$= qS_n^{(1)}(0,z)G_1^*(w)G_2^*(w)\left(\frac{1-G_3^*(k)}{k}\right). \tag{27}$$

$$\int_0^\infty M_n(x,z)\theta_3(x)dx = qS_n^{(1)}(0,z)G_1^*(w)G_2^*(w)G_3^*(k) \tag{28}$$

$$S_n^{(2)}(z) = S_n^{(2)}(0,z)\frac{(1-G_4{}^*(w))}{w}.$$

$$= rqS_n^{(1)}(0,z)G_1{}^*(w)G_2{}^*(w)G_3{}^*(k)\left[\frac{(1-G_4{}^*(w))}{w}\right]. \tag{29}$$

$$\int_0^\infty S_n^{(2)}(x,z)\theta_4(x)dx = rqS_n^{(1)}(0,z)G_1{}^*(w)G_2{}^*(w)G_3{}^*(k)\, G_4{}^*(w). \tag{30}$$

Using (28) and (30) in (18) we get,

$$S_n^{(1)}(0,z) = \frac{\lambda Q(E_k(z)-1)}{z-G_1{}^*(w)G_2{}^*(w)G_3{}^*(k)q[1+rG_4{}^*(w)]}\,. \tag{31}$$

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

To find the probability making limit of the line gauge paying little mind to the state of the structure.

Let $P_q(z)$ be the probability generating function of the Queue size.

Then adding (23), (25), (27) and (29), we get

Hence, $P_q(z) = S_n^{(1)}(z) + D_n(z) + M_n(z) + S_n^{(2)}(z)$

$$= \frac{Q\left\{\begin{matrix} -[1-G_1{}^*(w)+(1-G_2{}^*(w))G_1{}^*(w)+rqG_1{}^*(w)G_2{}^*(w)G_3{}^*(k)(1-G_4{}^*(w))]+ \\ qG_1{}^*(w)G_2{}^*(w)\frac{(1-G_3{}^*(k))}{k}\lambda(E_k(z)-1) \end{matrix}\right\}}{z-G_1{}^*(w)G_2{}^*(w)G_3{}^*(k)q[1+rG_4{}^*(w)]}. \quad (32)$$

6. RESULTS

The idle time Q is determined by using the normalization condition

$$P_q(1) + Q = 1$$

Using L'Hopital's rule, we get

$$\lim_{z\to 1} P_q(z) = \frac{N'(1)}{D'(1)}$$

Also $Q = \frac{D'(1)}{D'(1)+N'(1)}$

From Q, the utilization factor ρ can be determined.

Let L_q a chance to demonstrate the reliable state typical number of customers in the line. By then $L_q = \frac{d}{dz}P_q(z)\Big|_{z=1} = \frac{d}{dz}\left\{\frac{N(z)}{D(z)}\right\}\Big|_{z=1}$

Where $N(z)$ and $D(z)$ are the numerator and denominator of (32).

Since $P_q(z)= \frac{0}{0}$ at $z=1$, we utilize two-fold separation and get

$$L_q = \lim_{z\to 1}\frac{d}{dz}P_q(z) = \frac{D'(1)N''(1)-D''(1)N'(1).}{2(D'(1))^2}. \quad (33)$$

Where primes mean subordinates with respect to z and after a course of action of logarithmic enhancement, we get length of the queue L_q in closed frame.

 https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

$$N'(1) = -\{-\lambda E(G_1) - \lambda E(G_2) - rq\lambda E(G_4)\}. \quad (34)$$

$$N"(1) = -\Big\{-\lambda^2[E(G_1{}^2) + E(G_2{}^2)] + 2\lambda^2 E(G_1)E(G_2) - rq\lambda^2[E(G_4)][E(G_1) + E(G_2)] + rq\{(-\lambda+\gamma)E(G_3)(-\lambda)E(G_4) - E(G_4)\lambda^2[E(G_1) + E(G_2)] + \lambda E(G_4)(-\lambda+\gamma)E(G_3) - \lambda^2 E(G_4{}^2)\}\Big\} \quad (35)$$

$$D' = 1 - q\Big[(1+r)[\lambda(E(G_1) + E(G_2)) + (\lambda-\gamma)E(G_3) + r\lambda E(G_4)]\Big] \quad (36)$$

$$D" = -q\Big[(1+r)\Big[\lambda^2\Big(E(G_1{}^2) + E(G_2)E(G_1)\Big) + \lambda(-\gamma+\lambda)E(G_3)E(G_1)\Big] + r\lambda^2 E(G_1)E(G_4) + (1+r)\Big[\lambda^2\Big(E(G_2{}^2) + E(G_1)E(G_2)\Big) + \lambda(-\gamma+\lambda)E(G_3)E(G_2)\Big] + r\lambda^2 E(G_2)E(G_4) + (1+r)[(-\lambda+\gamma)(-\lambda)(E(G_1)E(G_3) + E(G_2)E(G_3)) + (-\lambda+\gamma)^2 E(G_3{}^2) + 2\gamma E(G_3)] + rE(G_4)\lambda E(G_3)(\lambda-\gamma) + \lambda r E(G_4)\{\lambda[E(G_1) + E(G_2)] + (\lambda-\gamma)E(G_3)\} + r\lambda^2 E(G_4{}^2)\Big] \quad (37)$$

Substituting for $N'(1)$, $N"(1)$, $D'(1)$, $D"(1)$ from (34) – (37) in (33), we obtain Lq in closed form.

Further the mean waiting time of a customer in the queue as well as in the system and the number of customers waiting in the system can be found using Little's formula $W_q = \frac{L_q}{\lambda}$, $W = \frac{L}{\lambda}$, $L = L_q + \rho$

7. NUMERICAL JUSTIFICATION OF THE MODEL

Assume that service time follows exponential distribution in particular and based on this condition, the numerical justification is elaborated below:

The values are collected accordingly: $\lambda = 2$, $\theta_1 = 5$, $r = 0.5$, $\gamma = 0.6$

$$E(G_1) = \frac{1}{\theta_1}, \quad E(G_2) = \frac{1}{\theta_2}, \quad E(G_3) = \frac{1}{\theta_3}, \quad E(G_4) = \frac{1}{\theta_4}, \quad E(G_1{}^2) = \frac{2}{\theta_1{}^2},$$

$$E(G_2{}^2) = \frac{2}{\theta_2{}^2}, \quad E(G_3{}^2) = \frac{2}{\theta_3{}^2}, E(G_4{}^2) = \frac{2}{\theta_4{}^2}$$

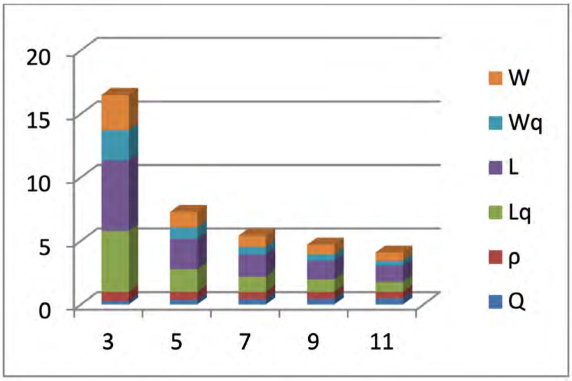
Table 1. Variation of θ_1=3,5,7,9,11.

Q	ρ	Lq	L	W_q	W
0.2770	0.7230	4.8008	5.5238	2.4004	2.7619
0.3817	0.6183	1.7827	2.4010	0.8914	1.2005

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

0.4346	0.5654	1.1901	1.7555	0.5951	0.8778
0.4667	0.5333	0.9656	1.4989	0.4828	0.7495
0.5019	0.4981	0.7789	1.2770	0.3895	0.6385

Source: own elaboration.



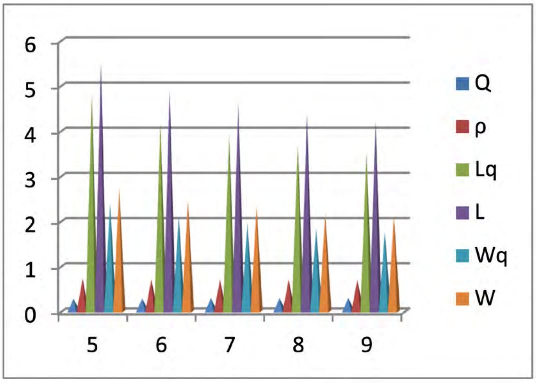
Graphic 3. Variation of θ_1.
Source: own elaboration.

Table 2. Variation of θ_2=5,6,7,8,9.

Q	***P***	***Lq***	***L***	W_q	***W***
0.2770	0.7230	4.8008	5.5238	2.4004	2.7619
0.2850	0.7150	4.1952	4.9102	2.0976	2.4551
0.2906	0.7094	3.9202	4.6296	1.9601	2.3148
0.2948	0.7052	3.6871	4.3923	1.8436	2.1962
0.2980	0.7020	3.5179	4.2199	1.7590	2.1100

Source: own elaboration.

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197



Graphic 4. Variation of θ_2.
Source: own elaboration.

8. NUMERICAL ANALYSIS

From Table1, it is identified that, if the process of completion of work in the first stage increases, it leads to a decrease in the length of the queue and also in the other performance measures. As the work gets completed sooner, the server idle time Q increases. Table 2 gives the fact that, as the probability of completion of vacation increase, it leads to an absence of a long queue in the communication process. It results in the decrease in waiting time of the process to be carried out in the queue as well as in the system. The results are as expected.

9. CONCLUSIONS

The Queuing procedure happening in the satellite communication procedure has been well analyzed in this paper. The Queuing problem is solved by means of supplementary variable method. The corresponding Queue execution measures are determined. The numerical illustration and the graphical picture well scrutinized the Queuing problem in satellite communication process. As a future work, obstruction can be brought into various stages. Furthermore, the possibility of Bernoulli move away could be added as it expects an obvious part taking everything together the coating structure. Equivalent examination of execution methods with this model can be appeared by including the parts of kept worthiness, balking in different stages, Priority alliance, set up time and multi move away from strategy. The system of need can be utilized in the above model and as a remarkable

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197

case this model can be diminished from that as of late arranged model. Retrial cooperation can be considered in this model.

REFERENCES

Chang, J.-F., & Lin, S.-H. (1993). Delay performance of VSAT- based satellite wide area networks. *International Journal of Satellite communications banner, 11*(1), 1-12. https://doi.org/10.1002/sat.4600110102

Fantacci, R., & Zoppi, L. (2000). Performance evaluation of polling systems for wireless local communication networks. *IEEE Transactions on vehicular technology, 49*(6), 2148-2157. https://ieeexplore.ieee.org/document/901886

Giambene, G., & Kota, S. (2006). Cross-layer protocol optimization for satellite communications networks: a survey. *International Journal of Satellite Communications and networking, 24*(5), 323-341. https://doi.org/10.1002/sat.853

Hung, A., Montpetit, M., & Kesidis, G. (1998). ATM via Satellite: A framework and implementation. *Springer wireless networks, 4*(2), 141-153. https://doi.org/10.1023/A:1019191619926

Lam, S. S. (1980). A carrier senses multiple access protocol for local networks. *Computer Networks, 4*(1), 21-32. https://doi.org/10.1016/0376-5075(80)90026-4

Louvros, S., Pylarinos, J., & Kotsopoulos, S. (2007). Handoff multiple queue model in microcellular networks. *Elsevier computer communications, 30*(2), 396-403. https://doi.org/10.1016/j.comcom.2006.09.008

Lutz, E. (1998). Issues in Satellite Personal Communication Systems. *Wireless networks, 4*, 109-124. https://doi.org/10.1023/A:1019187519018

Maragathasundari, S. (2015). A Bulk arrival queuing model of three stages of service with different vacation policies service interruption and delay time. *American International Journal of Research in Science and Technology, 11*(1), 52-56. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1043.2705&rep=rep1&type=pdf

Maragathasundari, S., & Karthikeyan, K. (2016). A Bulk queuing model of Optional second phase service with short and long vacations. *International Journal of Scientific Research in Science and Technology, 2*(5), 196-201. https://www.researchgate.net/publication/308917899_A_Bulk_Queuing_Model_of_Optional_Second_Phase_Service_with_Short_and_Long_Vacations

Maragathasundari, S., Anandapriya, B., Gothaiammal, S.B., & Gowri, V. (2017). M/G/1 Queue with restricted availability during service interruption and compulsory vacation of deterministic time. *International Journal of Mathematics Trends and Technology, 52*(1), 5-9.

Yeung, R. W., & Zhang, Z. (1999). Distributed source coding for satellite communications. *IEEE transactions on information theory, 45*(4), 1111-1120. https://ieeexplore.ieee.org/document/761254

Zaim, A. (2003). A markov model to calculate new and hand-off call blocking probabilities in LEO satellite networks. *Journal of Research and Practice in Information Technology, 35*(4), 271-283. https://search.informit.org/doi/abs/10.3316/ielapa.145199503050615

Zhu, J., Rao, Y., Fu, L., Chen, W., & Shao, X. (2012). Load Balancing Routing Based on Agent for Polar-orbit LEO satellite networks. *Journal of Information and computational science, 9*(5), 1373-1384. https://www.researchgate.net/publication/288271380_Load_balancing_routing_based_on_agent_for_polar-orbit_LEO_satellite_networks

https://doi.org/10.17993/3ctecno.2021.specialissue8.179-197